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# DESIGN OPTIMIZATION AND ANALYSIS OF COMPOSITE LEAF SPRING FOR LIGHT WEIGHT VEHICLE

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***ABSTRACT***

***Leaf spring is a traditional type of suspension system used in automobiles. It is the most comfortable device as compared with passengers, but due to its excessive weight, it is underestimated by the automobile sector. Leaf spring is only used in heavy transport vehicles due to high torque transmission required, vehicles easily sustain the load of 7 Steel Leafs. If the excessive weight of leaf spring means the weight of steel will be reduced then it is also very beneficial for light motor vehicles. Near about only 20% of unspring weight contributes by the leaf spring. So with a small amount of weight reduction will improve the comfort of passengers also it helps to minimize the vehicle cost. In this review paper steel is replaced by composite material with its specific design will be the best process of reduction in weight of leaf spring. Different design software can be used to achieve an optimistic design of leaf spring. A weight reduction is achieved only when a steel leaf spring is replaced with a mono composite spring under various conditions of design.***

***Key Words: Composite Design, Analysis of Leaf Spring, Light Weight Vehicle, Mono Composite Leaf Spring***

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## INTRODUCTION

Leaf springs are basically used in automobiles' suspension systems to absorb vibration produced due to road irregularities. Leaf spring is generally used in heavy duty trucks and in rail systems. It carries different loads, braking torque, driving thrust in addition to shock reduction. The main advantage of leaf spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. According to the studies made, a material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material for a leaf spring.

This part inspects the structure and re-enactment of leaf springs that basically withstand twisting. The leaf spring is the most widely recognized sort of composite spring. A leaf spring mounted a lengthways has a wheel driving capacity, including retention of brake powers and parallel powers. A transverse leaf spring has a wheel managing capacity that directs the spring pace of the haggle suspension of a vehicle. A transversal leaf spring is exposed to two unique loads in the vehicle. From one viewpoint, it assumes control over the ordinary lifting suspension of the pivot, and then again, contingent upon the structure, it assumes control over a few or the entirety of the necessary move adjustment of the hub. The lifting suspension can be portrayed as a symmetrical burden, since the two wheels move a similar way. For basic kinds of leaf spring, advancement investigation is performed and the rule mechanical highlights are clarified.

The basic advantage of composite material is that, if we make proper design, they will give the best result of composites. We can increase the property of composite material like strength, stiffness, corrosion resistance,

wears resistance, fatigue factor, weight reduction, attractiveness, thermal conductivity, thermal insulation, acoustical insulation, temperature dependent behavior, etc. Composite material mainly consists of a combination of Glass Fiber and polymers which are useful for many applications, mainly it is useful for reduction of weight. Many more advantages of Composite material instead of steel are: Noise reduction, minimizes vibrations and ride difficulties due to the damping force, corrosion resistant so maintenance cost is low and lower manufacturing cost.

## A. MATERIALS FOR LEAF SPRING

The main aim is to design a composite leaf spring over the replacement of seven-leaf steel spring of an automobile with a mono-leaf composite spring is the reduction of weight. The Input parameters for the Design of a spring is shown in table 1.

- Design load, W = 4000 N,
- Maximum allowable vertical defection, d max = 150 mm,
- Distance between eyes in straight condition, L = 1200 mm,
- Spring rate, K = 25-30 N/mm.
- Modulus of Elasticity=210 N/mm2
- Density=7800 Kg/m3
- Allowable Stress= 800N/mm2

**Table 1: The Input Parameters Considered for the Design of Leaf Spring in Both Cases**

| Parameters | Steel Spring | Composite Spring |
|---|---|---|
| Spring Length, mm | 1200 | 1200 |
| Arc Height (Camber), mm | 160 | 160 |
| Modulus of Elasticity, $N/mm^2$ | 210 $E^2$ | 32.5 $E^2$ |
| Material Density, $Kg/m^3$ | 7800 | 2600 |
| Load | 4000 | 4000 |
| Maximum allowable Stress, MPa | 800 | 550 |

## LITERATURE SURVEY

**Vikas Khatkar et. al.**

Composite materials were analysed for mechanical properties like tensile/compressive strength, flexural rigidity, impact strength. Also damping properties and wear resistant also investigated to know their uses as leaf spring material. In experimentation, it is found that 3D woven based composite leaf spring is significantly better than steel leaf spring, as compared with Unidirectional and 2-Dimensional parts with related to impact strength and improved energy storage. 3-Dimensional composite leaf spring showed high efficiency for the automotive sector of leaf spring. [1]

**T.G. Loganathan et. al.**

Automobile Leaf spring is the component that supports vehicle dynamics, in turn, travel comfort by offering required

stiffness. In this work, automobile leaf spring is the focus of study in terms of material change from the conventional SAE 5160 steel (Chromium steel) to CFRP (Carbon Reinforced Polymer Composite) to have considerable strength, associated weight reduction with minimized fuel consumption and increases the performance of the vehicle. The present work provides the results of flexural fatigue life and damage incurred for both the material by FE Analysis. In order to obtain better results of fatigue life of composite materials, various ply orientations are also considered. [2]

**Rama Krishna Reddy Guduru et. al.**

The mechanical properties of a leaf spring depend upon material type, manufacturing method, and composite material used. Some of the composite materials have a high stiffness ratio and maximum pressure as compared with metals, the Composite material strength depends upon size and shape. In this paper, the different mechanical properties studied related with composite materials to find out the best suitable composite material for the making of a mono composite leaf spring. The experimental test determined the weight, stiffness, and load-carrying capacity of the mono composite leaf spring. The experimental results show a reduction in weight near about of 65% and 70% respectively with the use of glass fiber epoxy resins. [3]

**K.Ashwini et. al.**

A Suspension system of a vehicle is the most common area for the researcher. Weight reduction can be achieved by using better material, optimistic design and advanced manufacturing processes. The suspension leaf spring is the major part for reduction of weight in automobiles as it accounts for 15-20% of the unspring weight. The composite material gives the chance for weight saving without changing the load carrying capacity. Many composite materials give the combination of maximum strength and minimum young's modulus. Epoxy resins are the most suitable material for a leaf spring. This paper is used for designing a leaf spring using various composites as the Automobile sectors are showing interest in replacing 7-steel leaf spring with composite leaf spring to obtain weight reduction, also used as energy conservation device because of reduction in weight the mileage of vehicle increases. [4]

**Jun Ke et. al.**

The design and Experimental investigation in the application field of composite material. This paper presents an overview of results on the selection of material, the design of the joint and the body structure of composite leaf springs, including the stiffness measurement method and optimization method. This paper also gives performance investigation results for the design, damping force, dynamic and moving stiffness, response to low impact, creep, fatigue life and loading condition of composite leaf springs. Finally, the emerging trends in the research of composite leaf springs are calculated.[5]

**T. Keerthi Vasan et. al.**

Traditional leaf spring may lead to failure due to variable load which causes an accident. Leaf springs are a conventional type of suspension system used in automobiles. The advantage of the automobile systems is based on the performance of leaf spring. Heavy weight of leaf spring is considered a disadvantage. To avoid this, researchers focus on a reduction in the weight of leaf spring with the help of composite materials. This paper presents how to reduce the weight of leaf spring by using composite materials like Glass, carbon, fibers and Epoxy material. The different equipment was prepared using layup method, they are carried out Flexural test, tensile test and Impact test. All results are figured out and compared. The composite leaf spring will give good performance when compared to a normal steel leaf spring. So selection of composite materials for the manufacturing of leaf spring will be a key factor.[6]

**Thippesh L et. al.**

The main function of the suspension system is to minimize road shocks. Composite material is useful for weight reduction as well as fuel consumption. A combination of good design and the best material also helps for weight reduction. A multi steel leaf spring can be replaced with a composite leaf spring. The mechanical and geometrical properties had a key role in better output. The main objective of a composite leaf spring is that it is capable of carrying external loads without failure. The stress produced in composite leaf spring as compared with steel leaf spring is considerably lower and higher frequency

**Erol Sancaktar et. al.**

In this paper, a functional composite leaf spring is designed for solar power operated vehicles. The weight reduction in solar operated vehicle is a primary concern. The unidirectional E-glass epoxy resins are used as a composite material. The experimental result analysis understands that the use and capabilities of E-glass epoxy resin as compared with other combinations of composite material was too good.

**Mahmood Shokrieh et. al.**

The 4 leaf steel leaf spring is used instead of 7 leaf steel leaf spring to reduce the same amount of weight as compared with composite material. The main objective is to develop a 4 leaf spring with minimum weight to sustain the static as well as dynamic load without failure. The observation result shows that if we decrease the width and increase the thickness of spring then the optimal result of weight reduction is achieved.

## OBJECTIVES OF PROPOSED RESEARCH WORK

The research described in this report had the following objectives:

- To define and evaluate the configuration of a light vehicle's composite leaf spring
- To compare the conventional mono and multi steel leaf spring with different mechanical properties of materials.
- To study the joint of the spring to the vehicle body, an additional lay-up was used on the spring end and the steel eyes were mounted through bolts.
- To develop the design theory of composite leaf springs which increase its applications in the automobile sector and other mechanical industries.

## CONCLUSIONS

This paper mainly focuses only on the literature review of previously published studies& research. The finding of this paper is right now the structure of leaf spring back suspension for back motor talked about. This is a nontraditional sort of suspension with leaf spring application for the back motor vehicle. Generally, for light business vehicles, the Engine is designed to locate at the front/center of the vehicle with differential. The structure of back suspension is confirmed and approved effectively for solidness and taking care of by doing limited component investigation and testing. Plan and assembling of a utilitarian composite spring for a solar operated vehicle is described. The aim is to give an optimistic product, use, and capability of composite leaf springs created for light vehicle applications where the vehicle weight is the main key factor. The present plan application includes sunlight based fueled vehicle

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